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Effects of Modified Skidding Rules on Mixed Conifer Advance Regeneration in Arizona

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Modified skidding rules, which included restricting equipment to precleared skid trails, and winching logs to the skid trails, plus directional felling, were used in a 40-acre special logging unit to evaluate the effects on advance regeneration. Logging resulted in a small (5%) decline in total advance regeneration density in skidding areas. Conifer density was decreased by 14%; but aspen sprouting made up the difference. Total stocking was unaffected. Losses in the special unit were less than in two adjacent areas logged by conventional methods.

Keywords: Timber harvesting, regeneration, logging damage, mixed conifers

Advance regeneration can contribute to the early restocking of a harvested stand if enough evenly distributed trees survive logging. However, conventional ground skidding within southwestern mixed conifer forests can excessively damage advance regeneration, reducing its abundance and distribution below acceptable levels. Gottfried (1983) found that 71% of the advance regeneration was destroyed, and that 64% of the sale area was inadequately stocked with conifers, following a diameter-limit harvest in eastern Arizona. A neighboring site, which was harvested by the selection method and had less overstory volume removed, suffered a 54% loss of advance regeneration; 53% of this area was inadequately stocked. The destruction of advance regeneration lengthens the next rotation, especially if the area does not regenerate naturally soon after harvesting. Tree planting, which is very expensive, may be the only alternative to achieve adequate stocking within the required 5 years of final harvest.

The losses which were reported by Gottfried and Jones (1975) and by Gottfried (1983), occurred even though care had been taken to avoid damage to the advance mixed conifer regeneration. Gottfried and Jones (1975) observed that much of the damage occurred during skidding operations and suggested three changes in logging procedures which should reduce damage.

1. Mark and clear skid trails before logging.
2. Restrict tractors to skid trails and require that logs be winched to the trails.
3. Vary log lengths to facilitate winching where regeneration is present.

The first change was designed to move logs efficiently and avoid sensitive areas. Skid trails are often made as needed during harvesting with no prior planning. Preclearing skid trails would allow for the removal of short sections of naturally fallen trees instead of the entire tree which would have to be moved or detoured around. These activities have caused damage to residual trees and to advance regeneration.

Restricting tractors to the designated skid trails would reduce machine-caused damage, but would require more winching. It could be necessary to have a swamper or choke setter working with the tractor to clear obstructing material from in front of the logs to prevent them from being caught and being dragged sideways.

Logs sometimes are difficult to winch, especially if they have large diameters and are in the standard, 32-foot lengths. Tractors often must leave the skid trail to manipulate the log around an obstruction or when it is felled at an adverse angle to the trail. Varying log lengths would make skidding easier, require less tractor time, and would reduce stand damage.

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In 1976, a 40-acre special logging unit was established within a standard mixed conifer timber sale. The objective was to determine if the proposed modifications prevented the degree of damage to advance regeneration which had been observed previously. The density and stocking of advance regeneration were compared before and after the harvest of the special unit, and with similar results from a surrounding sale logged by conventional procedures.

STUDY AREA

The special logging unit was within the South Thomas Timber Sale, on the Apache-Sitgreaves National Forests in east-central Arizona. The timber sale covered about 444 acres, with elevations ranging from 8,750 to 9,100 feet. The soils on the area, except in a small wet meadow, are sandy loams derived from basalt parent material and are classified as Mollic Eutroboralf loamy-skeletal, mixed (Sexton 1976). Slopes vary from 0% to 35%, but average 20%. The South Fork of Thomas Creek, an intermittent, gaged stream, originates and flows through the sale area. Average annual precipitation is 29.2 inches; about 55% falls mainly as snow between October and May. The 40-acre unit was established in the center of the sale area (fig. 1) and included sections on both sides of the stream channel. The unit was representative of the surrounding area. Elevations ranged from 8,800 to 9,000 feet.

Thomas Creek supported an old-growth, uneven-aged mixed conifer forest consisting of eight main species: Engelmann spruce (*Picea engelmannii*), blue spruce (*P. pungens*), Douglas-fir (*Pseudotsuga menziesii* var. *glauca*), white fir (*Abies concolor*), corkbark fir (*A. lasiocarpa* var. *arizonica*), ponderosa pine (*Pinus ponderosa*), southwestern white pine (*P. strobiformis*), and quaking aspen (*Populus tremuloides*). Douglas-fir was the most common species. New Mexico locust (*Robinia neomexicana*) occasionally was found in the understory. The stands consisted of a mosaic of groups and patches of varying size classes and species compositions.

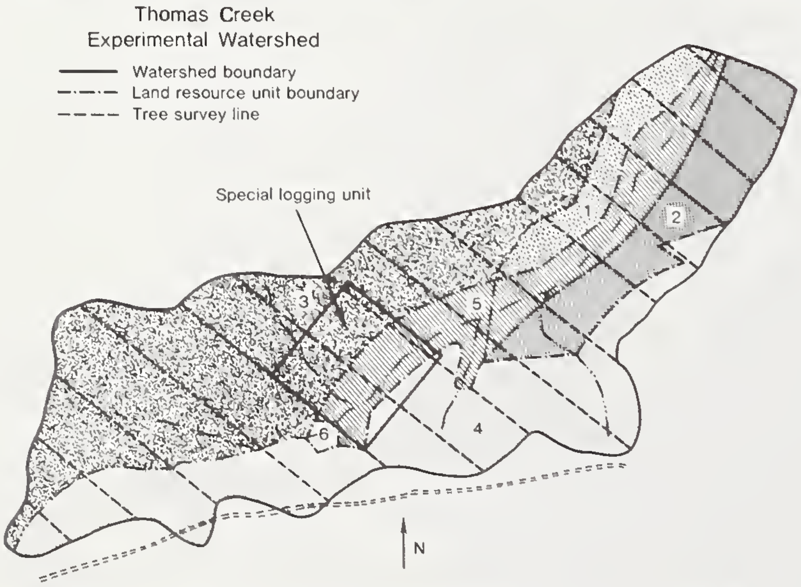

Figure 1.—The 40-acre special logging unit was in the middle of Thomas Creek. Land resource units 1, 2, and the lower part of 5 were not harvested because of locally steep slopes.

The entire 562-acre watershed originally had an average of 397 trees per acre equal to or greater than 1 inch d.b.h., and 186 square feet of basal area per acre. Initial stand data show that the 40-acre unit averaged 391 trees per acre, compared to 367 trees per acre for the surrounding 404-acre area. The basal area per acre values were 182 and 215 square feet, respectively. These data indicate that the 40-acre area had more smaller trees and less larger trees than the other area; however, the overall diameter distributions were similar. Species composition also varied with the special unit containing more blue spruce, corkbark fir, and ponderosa pine trees, and the adjacent area containing more white pine and aspen trees.

Silvicultural Prescription and Harvest

The prescription for the Thomas Creek Sale was designed to consider wildlife, water, and timber resources. The entire watershed was divided into several land resource units (fig. 1). The stand adjacent to the channel was harvested by individual tree selection; the south-facing slopes were harvested according to a group selection prescription designed to reduce basal area by 30%. The north-facing slope prescription called for patch clearcut harvesting, with individual tree selection in adjacent stands. Only the upper part of the watershed was harvested.

Six miles of logging roads were constructed during the fall of 1977. The main harvesting activities began in May 1978 and continued through January 1979, removing 3.4 million board feet net volume. The contractor used both rubber tire and tracked skidding equipment on the sale, although only a rubber tire skidder was used in the special logging unit. Slash was lopped on all areas except in fuelbreaks and along the channel; larger material was skidded to landings for disposal. Slash was piled in a watershed perimeter fuelbreak and in a 200-foot fuelbreak along logging roads, although the actual dimensions of the fuelbreaks varied with the density of fuels and with the percent slope. Piles were constructed in July 1979 and were burned in October 1980.

The standard contract was amended to allow the skidding rule modifications within the 40-acre special unit. The contract required precleared skid trails, winching logs to skid trails, and restricting equipment to designated skid trails. Tractors were required to be capable of winching logs 75 feet. Provisions for varying log lengths were not included. These changes are not specified in the current timber sale contract. The standard 1973 contract, which is still used, states that the location of all skid trails, tractor roads, and landings are to be agreed upon prior to construction, but does not allow for much planning for cleared skid trails, or for restricting tractors to skid trails. It calls for the protection of advance regeneration and for winching; but does not require the removal of downed material to facilitate winching. However, the sale administrator has some latitude within the standard contract to request modifications in skidding rules.

Skid trails in the special unit usually looped between landings, so that logs could be moved in either direction (fig. 2). There were approximately 1.8 miles of skid trails in this unit. Trails generally were 10 feet wide. The logging contractor voluntarily agreed to directional felling to make winching and skidding easier. The skidder operator set his own chokes.

METHODS

The main approach was to compare advance regeneration density and stocking before and after a harvest using the modified skidding rules. The objective was to see if the regeneration decreased or was unaffected by the modifications. The first hypothesis was that the modified rules would not cause large declines in the advance regeneration. The second hypothesis was that the special unit would contain more residual advance regeneration than a similar conventionally logged unit. Scheduling difficulties prevented establishment of a second 40-acre plot; so results from the special unit were compared to the surrounding sale area (the main unit) to determine if postharvest conditions were different.

The 40-acre unit was in the center of the Thomas Creek sale area (fig. 1). The unit was laid out as a square, 1,320 feet on a side. The entire area was surrounded by a 33-foot buffer strip with clearly marked exterior boundaries. A baseline was established, and transects were set at right angles. A systematic sampling design was used with transects spaced at 66-foot intervals. This would have resulted in 21 transects; but 19 were used to take advantage of 3 existing overstory inventory lines.

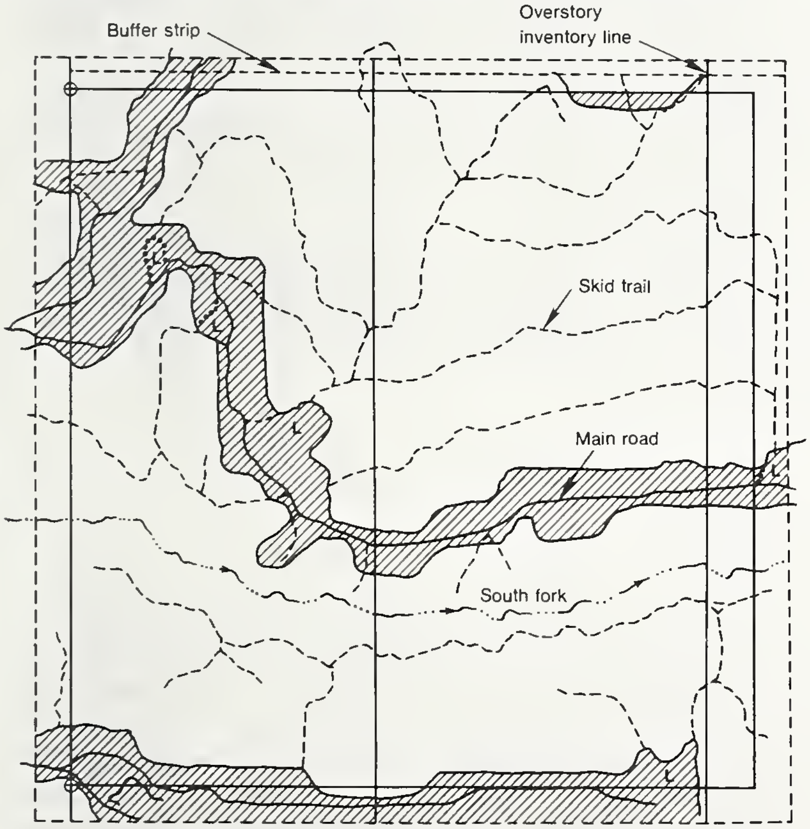

Figure 2.—Skid trails in the special unit were designed to move logs efficiently to the main landings (L). Approximately 6.2 acres of the special unit were influenced by roads, landings, or by slash disposal activities.

Advance regeneration was measured on 399 4-milacre (0.004-acre) plots which were established at 66-foot intervals along the transects. The actual plots were offset 15 feet at right angles from the line to avoid any damage to regeneration during plot and line establishment. The point on the transect corresponding to each plot was staked. The same plots were measured during both inventories.

Advance regeneration included all trees between 3 inches in height and less than 7.0 inches d.b.h. that could be considered growing stock; a tree had to have satisfactory growth and form, no major damage and no dwarf mistletoe. Trees were divided into three classes:

Small seedlings	3 inches to 0.9 feet in height
Established seedlings	1 foot in height to 0.9 inch d.b.h.
Saplings-small poles	1.0 inch to 6.9 inches d.b.h.

Trees were tallied by species. A 4-milacre plot was considered stocked if it contained at least one acceptable tree of any size class. However, a second level of stocking (i.e., two trees in a plot) is also shown because of the uncertainty of what constitutes optimum stocking in mixed conifer stands. Stocking levels were compared using the chi-square test.

Plots were established and measured during the summer of 1976. However, 1 year later, when road construction finally began, the 40-acre unit was found to contain a very high concentration of roads. There were roads along the north and south boundaries and two roads crossing through the unit (fig. 2). All roads were later associated with some type of slash disposal activity. This provided a confounding activity because the study was concerned with skidding, not road effects. Seventy-one plots were within the 6.2 acres that were influenced by roads, landings, or slash disposal. The final measurement, during the summer of 1982, reflected both logging effects, subsequent ingrowth, and growth among size classes over the previous years. Because the same 4-milacre plots were measured during both inventories, a paired t-test was used to evaluate changes caused by treatment. Statistical significance was indicated by values above the 5% level.

The Main Sale Unit

To compare posttreatment conditions between the two units, it was necessary to establish if pretreatment advance regeneration parameters were similar. The unit was not surveyed in 1976; however, a 1969 inventory which covered the entire watershed provided comparable data. The plots were laid out according to the multiple random start design used for the overstory inventory (fig. 1). The 1969 survey measured trees in the established seedling and sapling-small pole size classes. The small seedling class was not included. There were 5 of the old plots in the 40-acre unit and 38 in the main unit. Small trees were measured on 0.04-acre plots, and saplings-small poles were measured on 0.10-acre plots.

The data were evaluated by the t-test. In some analyses, the t-test had to be modified to account for unequal variances.

The 1982 advance regeneration inventory used 4-milacre plots and the same procedures as were used in the 40-acre unit. Plots were located at 66-foot intervals along the sections of the main watershed inventory lines which were within the unit (fig. 1). The actual plots were offset 15 feet on both sides of the line. There were 484 plots. The impact of road or slash disposal activities was noted on 54 plots. A t-test was used to evaluate differences between the two units.

Overstory Measurements

Overstory measurements were made using point sampling techniques based on a 25 basal area factor (BAF) wedge. The points were permanently established on inventory lines which crossed the watershed perpendicular to the stream channel (fig. 1). The main unit contained 69 inventory points, while the 40-acre special unit contained 16 points. An additional 35 inventory points were randomly selected in the special logging unit from among the 399 plot locations, to give a total of 51 points. The watershed was inventoried in 1974 and in 1979. The supplemental points were measured in 1977 and in 1980.

RESULTS

Overstory

There were initially more trees larger than 20 inches d.b.h. in the main unit than in the special unit; but the total number of pole and sawtimber trees were the same. The main area also contained a greater volume. The harvest removed an equal proportion of the trees and basal area per acre on both sites (table 1). A slightly smaller percentage of the initial total tree volume was removed on the main unit; but the actual volumes were relatively similar (i.e., 9,149 and 10,535 board feet per acre). The postharvest values include some unsalvaged mortality, for example, caused by wind.

Special Logging Unit

Density

The number of trees per acre by species and size class were compared before and after harvesting. It was anticipated that the modified skidding rules would result in minor damage to the advance regeneration. The values reflect some ingrowth into the smallest size class and growth among size classes. The results (table 2A) indicate that the overall decline of 148 trees per acre in the skidding areas, away from the influence of roads and slash disposal, was small (5%) and nonsignificant. However, changes by size class showed significance as did overall changes for white fir, white pine, and aspen. White fir, the most common tree in the advance regeneration, showed an overall decline of 22%, while aspen showed an overall increase of 205%. The small seedling and the sapling-small pole size classes had significant declines of 21% and 16%, respectively. The established seedling class, however, gained 328 trees per acre for a 51% increase, primarily because of the abundant sprouting and rapid growth of the pioneer aspen.

If this data set is analyzed for conifers only, the results indicate that there is a very significant overall decline of about 14%. The changes for the small seedling and for the sapling-small pole classes would still be significant, while the increase in the established seedling class would be minor. The data indicates significant changes for some of the species-size class combinations (table 2A).

The comparisons for the entire 40 acres (table 2B) indicate that the overall decline of 352 trees per acre (12%) was significant. The other results with and without aspen are similar to those for just the skidding plots. There are a few additional species-size class differences.

Stocking

The harvest, using the modified rules, had little effect on the overall stocking of commercial species in the special unit skidding areas; stocking remained at 95% between 1976 and 1982 (table 3). Many of the stocking changes observed (table 3) were statistically significant because of the large sample sizes; however, changes of 3% or 5% are not too large from a management position. The stocking of conifers declined from 94% to 88%, while the stocking of aspen essentially doubled. Aspen was the only species on 8% of the plots, an increase of 7%. Aspen occupied several plots where conifers had been destroyed. Stocking changes were greater for the entire 40 acres, reflecting the impact of road construction, log landings, and slash disposal. The unit remained well stocked, or moderately stocked, if the two tree criteria is used.

Stocking changes for the three size classes were minor and generally nonsignificant in the special unit (table 3). The greatest changes in the entire unit were for the seedling and the sapling-small pole classes; this supports the significant declines in density for the classes.

Main Unit vs. Special Unit

Density

The 1969 inventory indicated that the two units had similar populations of established seedlings, saplings-small poles, and of total trees. The species comparisons for the seedling and tree total categories also showed no difference between areas. The species comparisons for the sapling-small pole class found more ponderosa pine and aspen in the main unit. However, these differences were not considered enough to prevent the postharvest comparison between units.

The data (table 4) shows that there were more small trees in the skidding areas of the special unit (2,823 trees)

Table 1.—Overstory conditions per acre (based on a 25 BAF inventory of trees 7 inches d.b.h. and larger).

	40-Acre Logging Unit						Main Logging Unit					
	Before harvest			After harvest			Before harvest			After harvest		
	Trees	Basal area ft^2	Board foot volume[1]	Trees	Basal area ft^2	Board foot volume	Trees	Basal area ft^2	Board foot volume	Trees	Basal area ft^2	Board foot volume
Engelmann spruce	12	11	1,607	8	8	1,354	13	13	1,952	11	10	1,550
Blue spruce	17	12	1,453	10	8	1,126	4	5	937	3	3	627
Douglas-fir	40	48	5,849	32	31	3,216	42	65	8,913	30	39	5,176
White fir	15	24	3,885	8	14	2,315	23	41	6,977	17	24	4,052
Corkbark fir	10	7	714	10	7	604	4	3	381	4	3	330
Ponderosa pine	13	26	5,380	8	11	1,902	16	30	5,976	12	19	3,742
S.W. white pine	22	22	2,782	19	18	2,192	12	17	2,305	9	11	1,520
Quaking aspen	15	9	768	10	6	580	29	19	2,201	17	17	2,110
Totals	144	159	22,438	105	103	13,289	143	193	29,642	103	126	19,107
Percent reduction				27	35	41				28	35	36

[1] *Scribner Decimal C*

Table 2A.—Declines (-) or gains (+) in advance regeneration density (trees per acre) for the skidding areas within the 40-acre special logging unit.

	1976 Preharvest conditions				Declines (-) or gains (+) by 1982			
Species	Small seedlings	Est. seedlings	Saplings-small poles	Total	Small seedlings	Est. seedlings	Saplings-small poles	Net losses or gains
Engelmann spruce	147.1	57.2	32.0	236.3	-33.5	-15.3	-13.7*[1]	-62.5
Blue spruce	6.9	24.4	33.5	64.8	+12.9*	+5.3	-9.9	+8.3
Douglas-fir	247.0	202.7	115.1	564.8	+17.5	-35.8	-2.3	-20.6
White fir	849.8	209.6	110.5	1169.9	-305.6**	+55.6*	-8.4	-258.4**
Corkbark fir	516.0	88.4	26.7	631.1	-104.4*	+74.7**	+1.5	-28.2
Ponderosa pine	3.8	3.8	6.1	13.7	+2.3	+3.8	-0.8	+5.3
S.W. white pine	84.6	26.7	50.3	161.6	-40.4**	+4.5	-20.6**	-56.5**
Quaking aspen	72.4	30.5	25.9	128.8	+39.6**	+235.5**	-10.7	+264.4**
Total	1927.6	643.3	400.1	2971.0	-411.6**	+328.3**	-64.9**	-148.2

[1] **Differences significant at the 5% level.*
***Differences significant at the 1% level.*

Table 2B.—Declines (-) or gains (+) in advance regeneration density (trees per acre) for the entire 40-acre special logging unit.

	1976 Preharvest conditions				Declines (-) or gains (+) by 1982			
Species	Small seedlings	Est. seedlings	Saplings-small poles	Total	Small seedlings	Est. seedlings	Saplings-small poles	Net losses or gains
Engelmann spruce	125.9	48.9	28.2	203.0	-29.4	-13.8	-11.3*	-54.5
Blue spruce	5.6	23.8	32.0	61.4	+11.3*	+0.6	-8.8*	+ 3.1
Douglas-fir	245.0	197.4	109.0	551.4	-5.6	-52.6**	-11.3	-69.5
White fir	881.0	197.4	105.3	1183.7	-411.7**	+42.6	-17.5	-386.6**
Corkbark fir	438.6	81.4	21.9	541.9	-95.9**	+55.8*	+1.2	-38.9
Ponderosa pine	3.8	3.8	6.9	14.5	+3.1	+2.5	-1.2	+4.4
S.W. white pine	91.5	25.7	48.9	166.1	-53.3**	+1.9	-20.7**	-72.1**
Aspen	78.3	29.4	23.8	131.5	+43.9**	+229.3**	-10.6*	+262.6**
Total	1869.7	607.8	376.0	2853.5	-537.6**	+266.3**	-80.2**	-351.5**

Table 3.—Preharvest (1976) and postharvest (1982) advance regeneration stocking for the special logging unit (based on 4-milacre quadrats).

	Skidding area		40-acres	
Amount of stocking	1976	1982	1976	1982
	--------- *percent* ---------			
Stocked with at least				
1 conifer	94	88**	94	81**
2 conifers	56	51	54	44**
Stocked with at least				
1 aspen	25	51**	25	50**
2 aspens	13	30**	13	31**
Stocked only with aspen	1	8**	1	8**
Stocked with at least				
1 tree	95	95	94	89*
2 trees	57	56	55	49
Stocked with at least				
1 small seedling	72	69	72	63**
2 small seedlings	62	56	62	50**
Stocked with at least				
1 established seedling	67	65	66	59*
2 established seedlings	46	49	45	43
Stocked with at least				
1 sapling-small pole	62	54*	61	48**
2 saplings-small poles	38	33	36	30

than in the main unit (2,212 trees). The main unit also contained fewer small seedings and saplings-small poles. There were no differences for the established seedling class. Some differences occurred for several species-size class combinations. The relatively high survival of corkbark fir in the special unit could reflect locally heavy regeneration which was too small in 1969 to be counted, or heavier damage to corkbark fir during the harvest in the main unit. The 1969 comparison showed no differences in corkbark fir. The skidding areas of the special unit showed a loss of 28 corkbark fir per acre (table 2A); however, many trees advanced from the small seedling to the established seedling class, or appeared as ingrowth. Conditions in the entire main unit were similar to those described for its skidding areas, except for the lack of differences for the Douglas-fir sapling-small pole size class.

Stocking

Eighty-nine percent of the plots in the skidding areas of the main unit (table 5) were stocked with at least one tree. This is significantly less than the 95% value for the special unit. Both areas would be considered well stocked, however. Aspen stocking was slightly greater by 3% in the main unit, reflecting the density difference of 93 more trees per acre (table 4). Differences between the entire main unit and special unit were slightly smaller.

The various size classes (table 5) were less well distributed in the skidding areas of the main unit than in the special unit. The greatest stocking differences were for the small seedling and sapling-small pole classes. This agrees with the density comparisons (table 4).

DISCUSSION AND CONCLUSIONS

Results from the skidding areas of the special logging unit indicated that the overall advance regeneration decline of 5% (table 2A) was not significant. However, this reflects the impact of vigorous aspen sprouting throughout the area. Aspen showed an increase of about 205% and now makes up 14% of the regeneration, an increase of 10%. Losses to the conifer component were significant at about 14%. Significant declines also were noted for the small seedling and for the sapling-small pole size classes, and for several species-size class combinations. Overall stocking did not change (table 3), although conifer stocking declined by 6% while the proportion of plots with aspen more than doubled. More than 50% of the plots now contain at least one aspen tree.

Table 4.—Advance regeneration density (trees per acre) for the skidding areas of the two Thomas Creek logging units in 1982.

	Special unit				Main unit			
Species	Small seedlings	Est. seedlings	Saplings-small poles	Total	Small seedlings	Est. seedlings	Saplings-small poles	Total
Engelmann spruce	113.6	41.9	18.3	173.8	77.3	34.9	16.3	128.5
Blue spruce	19.8	29.7	23.6	73.1	4.6*	21.5	9.3*	35.4**
Douglas-fir	264.5	166.9	112.8	544.2	209.3	141.9	79.6*	430.8*
White fir	544.2	265.2	102.1	911.5	570.3	271.5	76.2	918.0
Corkbark fir	411.6	163.1	28.2	602.9	28.5**	44.2**	6.4**	79.1**
Ponderosa pine	6.1	7.6	5.3	19.0	17.4	2.9	4.1	24.4
S.W. white pine	44.2	31.2	29.7	105.1	28.5	39.5	15.7*	83.7
Quaking aspen	112.0	266.0	15.2	393.2	136.0	339.5	11.0	486.5
New Mexico locust	0	0	0	0	19.8**	5.8**	0	25.6**
Total	1516.0	971.6	335.2	2822.8	1091.7*	901.7	218.6**	2212.0**

Comparisons for the entire 40 acres indicated an overall density decline of 12%.

The special unit contained significantly more trees per acre than the surrounding main unit, which was logged according to standard procedures (table 4). However, this difference was strongly influenced by a population of vigorous corkbark fir. The main unit had 610 fewer trees, but still had 2,200 trees per acre. Overall stocking was 6% less on the main unit; but the unit was still well stocked.

The initial hypothesis was that the modified rules would not cause large declines in the advance regeneration components. Although some significant changes were noted by the statistical evaluations, these changes were relatively minor. The 2,800 trees per acre, or 2,400 conifers per acre, should be sufficient to replace the 39 trees per acre which were harvested. Stand composition and structure should not really change. The increase in number of aspen is normal after any disturbance in mixed conifer stands; however, the shade intolerant aspen will decline as the overstory canopy closes again. Aspen will only maintain itself in larger openings. The temporary increase would be beneficial for a number of wildlife species. The distribution of stocked plots was unchanged; the unit remains well stocked with commercial species. Skidding caused so little damage in some areas that it was often difficult to identify cutting sites without first locating a fresh stump (fig. 3) or cut branches.

The second hypothesis was that the special unit would contain more residual advance regeneration than the main unit. Statistical evaluations indicated significant differences between the units. However, the main unit maintained satisfactory levels of advance regeneration despite the lower density and stocking values. The standard skidding procedure resulted in less damage than normally observed elsewhere. This could be attributed to close sale administration, coupled with a cooperative logging contractor.

Table 5.—Comparison of advance regeneration stocking for the special and main logging units (based on 4-milacre quadrats).

Amount of stocking	Skidding area		Entire area	
	Special unit	Main unit	Special unit	Main unit
	----------- *percent* -----------			
Stocked with at least				
1 conifer	88	80**	81	75*
2 conifers	51	42*	44	39
Stocked with at least				
1 aspen	51	54	50	51
2 aspens	30	39**	31	38*
Stocked only with aspen	8	9	8	9
Stocked with at least				
1 tree	95	89**	89	84*
2 trees	56	50	49	47
Stocked with at least				
1 small seedling	69	55**	63	52**
2 small seedlings	56	41**	50	39**
Stocked with at least				
1 established seedling	65	60**	59	55
2 established seedlings	49	40*	43	37
Stocked with at least				
1 sapling-pole	54	42**	48	38**
2 saplings-small poles	33	20**	30	19**

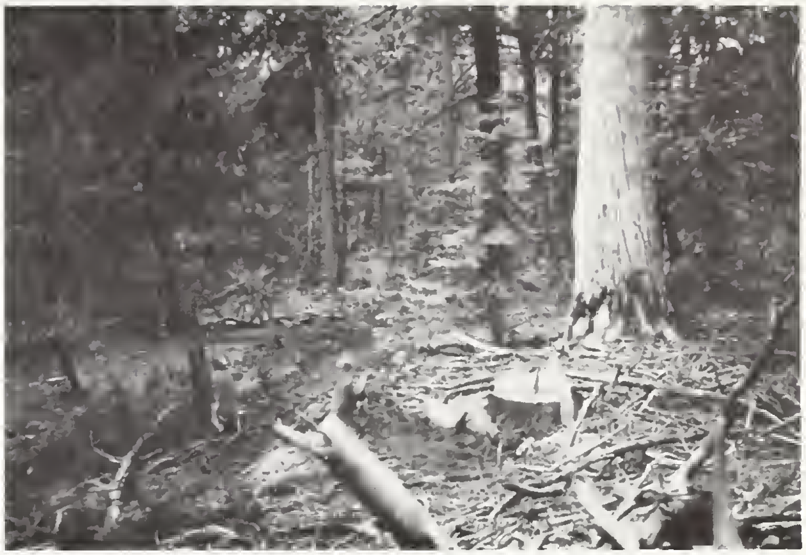

Figure 3.—There was usually little damage to advance regeneration or soil disturbance where logs had been winched to the skid trails.

The findings from the two Thomas Creek units contrast sharply with those from the neighboring mixed conifer stand at Willow Creek (Gottfried 1983). The selection area prescription included both single tree and small group selection methods, and resulted in a 29% reduction in basal area and a 25% or 5,900 board feet per acre reduction in volume. These removals caused an initial loss of 54% of the advance regeneration. Full recovery only was attained 6 years after the harvest, when approximately 2,800 trees per acre were surveyed. Thirty-six percent of these trees were aspen. Both of the Thomas Creek areas were in better condition within 3 years after harvest despite heavier volume and basal area reductions.

The modified skidding rules resulted in minimal losses to advance regeneration. However, it can be argued that the main unit was not devastated by a conventional operation, and that the modifications result in extra work with only a small benefit. The satisfactory situation here has been attributed to the good working relationship between the sale administrator and the contractor. There were significant differences between the two units despite the cooperation.

Another argument against the rules could be that Willow Creek recovered in 6 years, even after heavy damage, so why go through the trouble for a 3-year earlier recovery? Three years is extremely important in the life of a young tree. If these procedural changes can result in immediate recovery, why gamble on a longer recovery period, especially considering the variability of climatic and ecological conditions in the Southwest? Although conifers increased on Willow Creek, the recovery depended heavily on aspen sprouting. Aspen is beneficial for wildlife and is esthetically pleasing; but conifers are normally favored under most current silvicultural prescriptions.

Thomas Creek was just one test; additional evaluations should be conducted in different geographic locations and under different stand and site conditions. If the modified skidding rules are proven beneficial, then the standard timber sale contract should be changed accordingly.

Several studies in the other parts of the West have looked at the effects of many of the recommended skidding modifications on residual tree damage, machine productivity, and on site disturbances. Aho et al. (1983), working in California, found that between 22% to 50% of the residual white fir and red fir (*A. magnifica*) trees were damaged after commercial thinning operations which used conventional techniques. However, only 5% to 14% of the residual trees were damaged when modified procedures were used. Aho et al. (1983) stressed the value of prior layout and clearing of skid trails as well as limiting log lengths and of directional felling.

Olsen and Seifert (1984) studied designated and undesignated skid trails in Idaho, and found that 13% fewer plots were affected by machine activity in the designated trail area. Total mortality from machines and felling was still 48% in the designated area; but this was 5% less than in conventionally logged sites. Productivity generally increased on designated trails. Premarked skid trails and winching also were studied by Froehlich et al. (1981). They found slightly higher productivity when premarked trails were used since restricting equipment reduced unnecessary maneuvering and cycle time. In addition, only 10% of the area was disturbed with marked trails compared to 26% for the usual skidding method. This reduction in skid trail coverage was also beneficial for site productivity, because trees growing in compacted soil in skid trails often have large reductions in height and stem growth (Froehlich et al. 1981, Froehlich and McNabb 1984).

Damage to residual trees in the study of Froehlich et al. (1981) was 9% on the marked skid trail unit, 21% less than on the conventional side. Bradshaw (1979) indicated disturbance values of 4% and 22% for these two procedures, respectively. It is logical to assume that less disturbance can be equated to less damage to the residual stand. Bradshaw (1979) did find that marked trails and winching increased logging costs by 29%, although he attributed the increase to winching. In contrast, Cole (1983) found identical damage to residual trees under either strategy in young growth redwood (*Sequoia sempervirens*)/Douglas-fir stands in California. However, he favored preplanned skid trails because they gave the landowners more control over operations and can be used in subsequent operations with little additional site disturbance.

The modified skidding rules used at Thomas Creek limited losses of advance regeneration to 5% and maintained stocking at 95%. Even though some comparisons indicated statistical differences, for example, in conifer density or certain size classes, the overall effect was small. The conventionally logged main unit showed greater declines in density and stocking levels than the special unit, but was still in satisfactory condition. Declines on both units were minor when compared to more typical losses in the adjacent Willow Creek area which had been logged by conventional methods. Studies in other regions of the West, for example, Aho et al. (1983), Olsen and Seifert (1984), Froehlich et al. (1981), have also shown the benefit of similar modified skidding rules on reduced stand and site damage, and often on increased productivity.

Logging production was not considered in this case study; but it is an area that needs attention. Benefits to the residual stand in accelerated rotations and reduced regeneration costs should be sufficient to warrant consideration of these modifications for changes to the required sections of the standard sale contract. Proof of increased productivity would make the changes more acceptable to logging contractors.

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